Asymmetry of Jet k_T in Longitudinal Polarized p+p Collisions in PHENIX at RHIC

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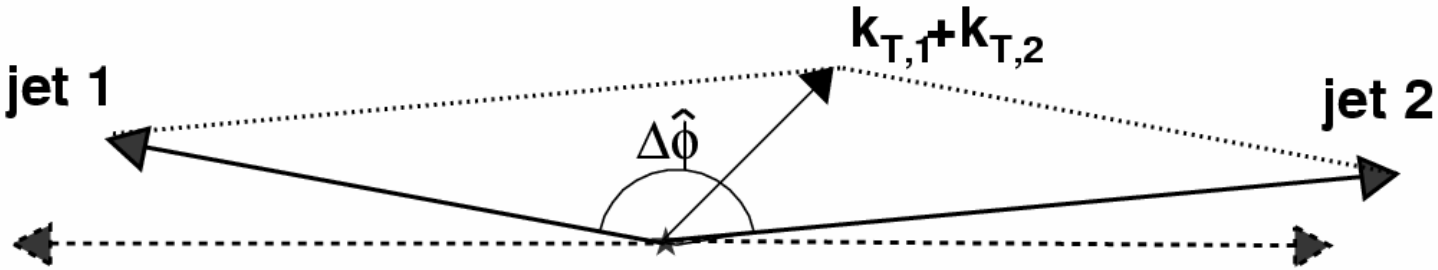
Outline

- Measuring transverse momentum of partons in the proton
- Looking for a correlation of this measurement with spin direction
- Initial measurements in Run03
- Status of Run05
- Summary

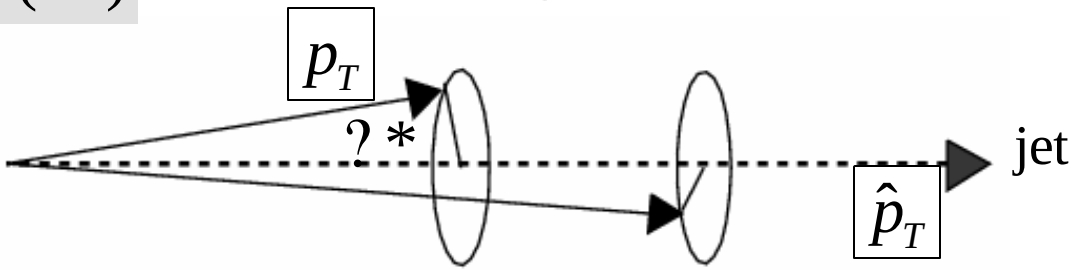
k_T, j_T from azimuthal correl.

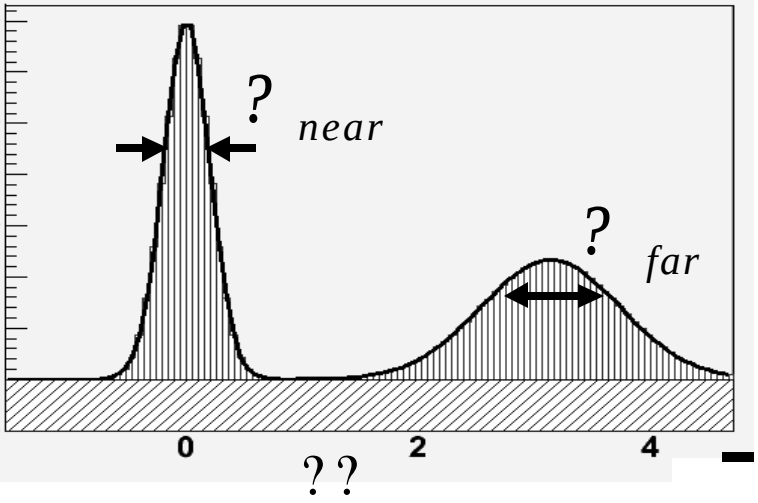


$j_T \approx \hat{p}_T \sin(\phi^*)$

fragmentation

$z \approx \frac{p_T \cos(\phi^*)}{\hat{p}_T}$





$\langle j_T \rangle \approx \langle k_T \rangle_N$

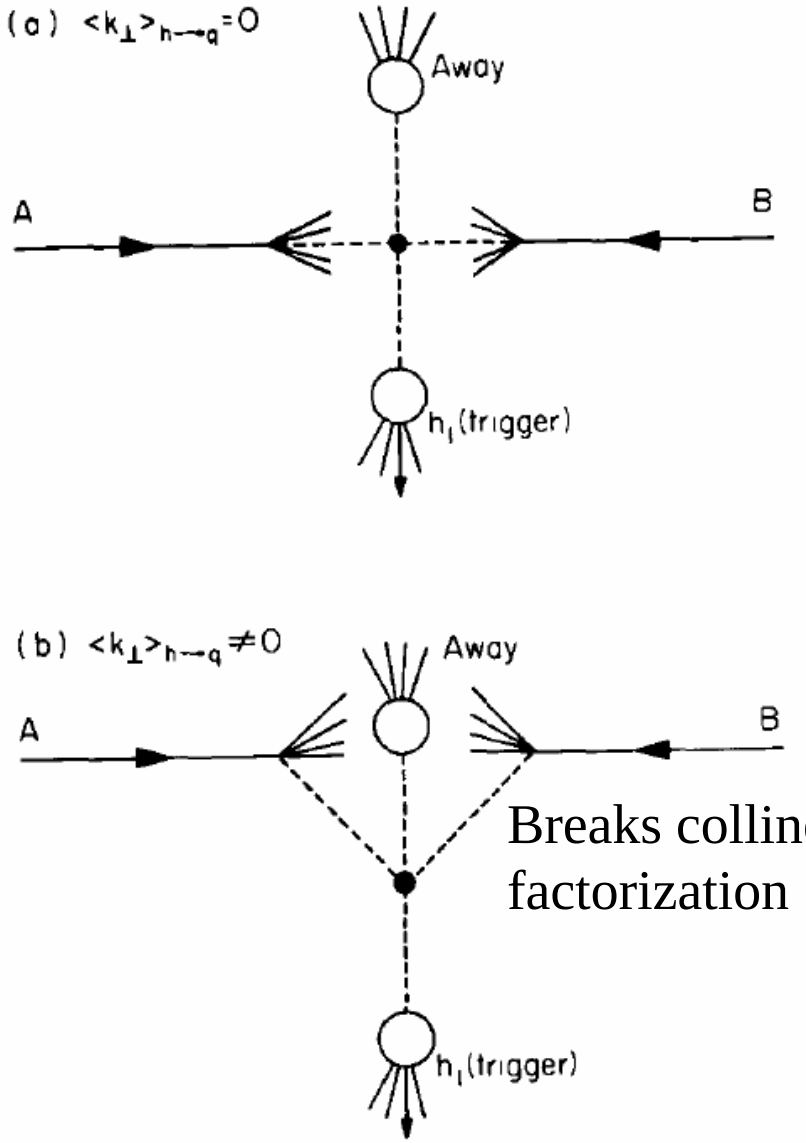
jet fragmentation transverse momentum, j_T-scaling.

$\langle k_T \rangle \approx \langle k_T^2 \rangle_F - \langle k_T^2 \rangle_N$

parton transverse momentum, intrinsic + NLO radiative corrections.

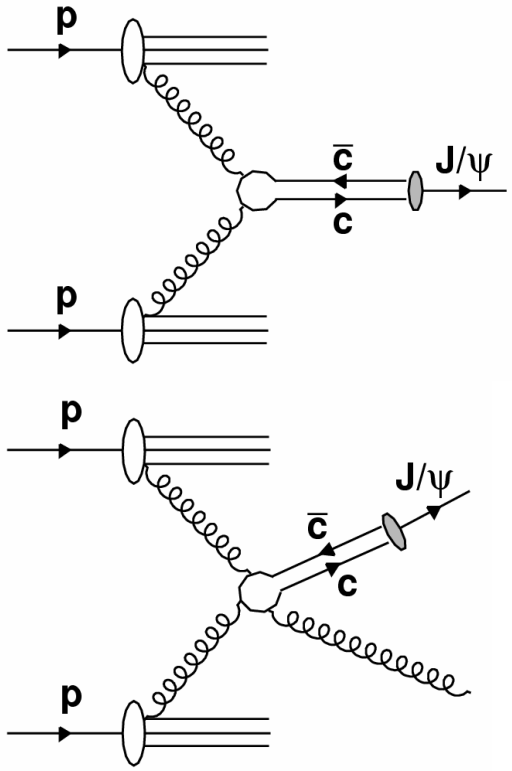
Origin of k_T

$$\frac{1}{2}\left\langle p_T^2\right\rangle_{pair} ? \left\langle k_T^2\right\rangle \quad ? \quad \left\langle k_T^2\right\rangle_{\text{intrinsic}} ? \left\langle k_T^2\right\rangle_{\text{soft}} ? \left\langle k_T^2\right\rangle_{\text{NL O}}$$



Breaks collinear factorization

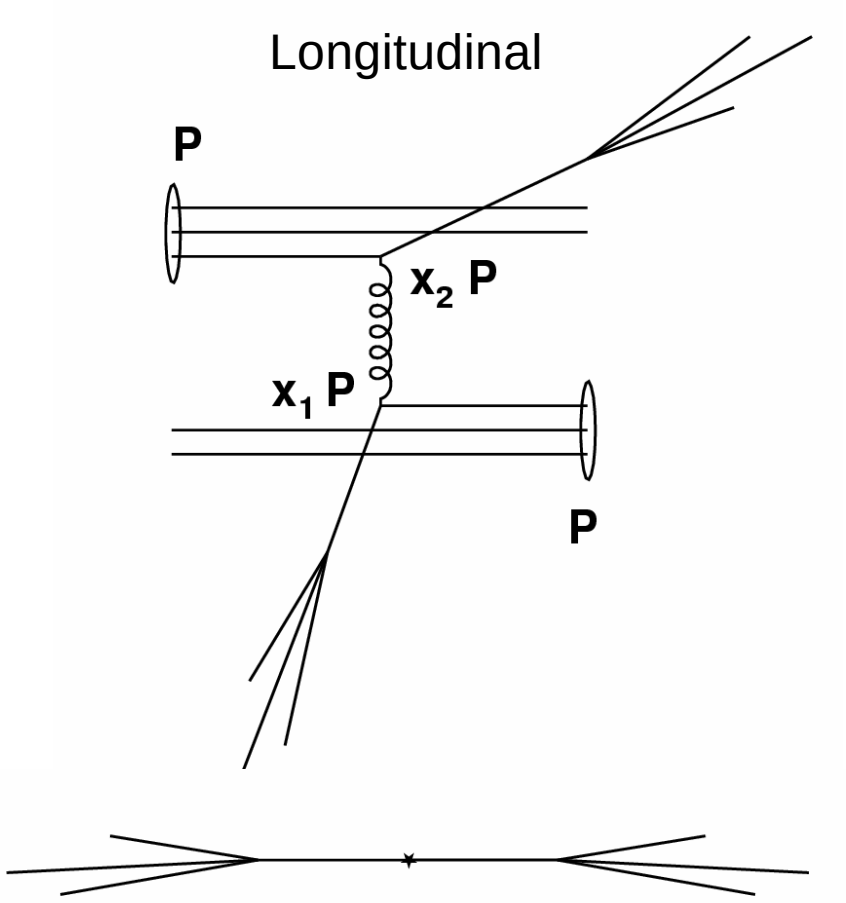
An example - J/? production.



$?p_T?_{J/?} = 1.8?0.23?0.16$ GeV/c

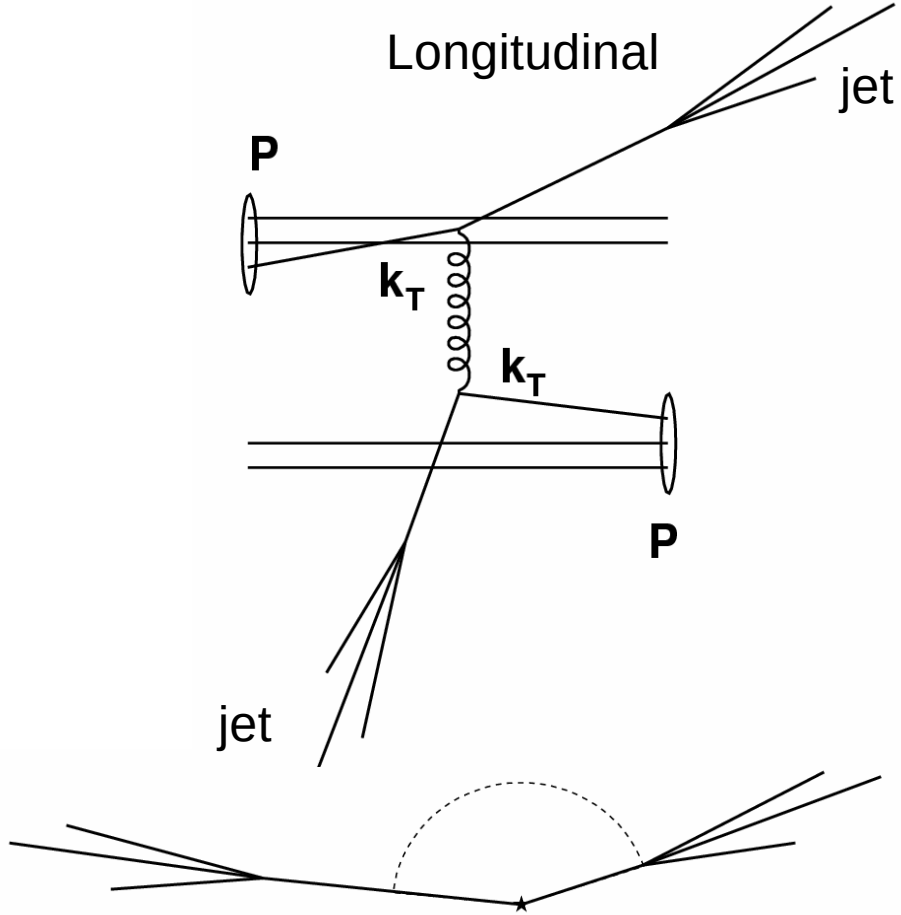
Phys. Rev. Lett. 92, 051802, (2004).

Hard Scattering k_T



transverse

- acoplanar in P_L ? P_T space
- collinear in P_X ? P_Y space



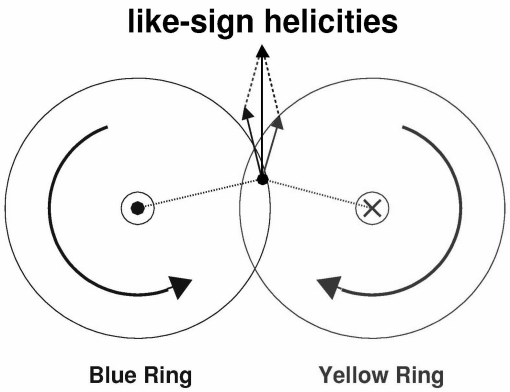
transverse

- acoplanar in P_L ? P_T space
- acoplanar in P_X ? P_Y space

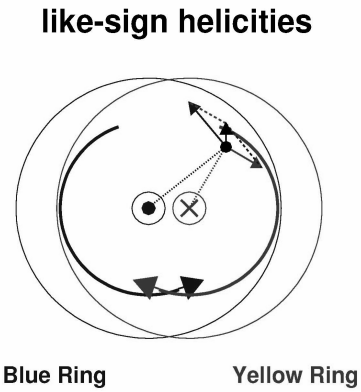
k_T from Orbital Motion

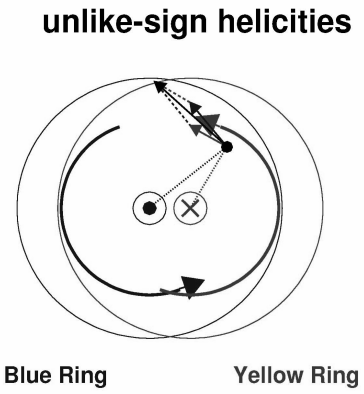
One can consider the possibility that spin-correlated transverse momentum (orbital angular momentum) may contribute to jet k_T.

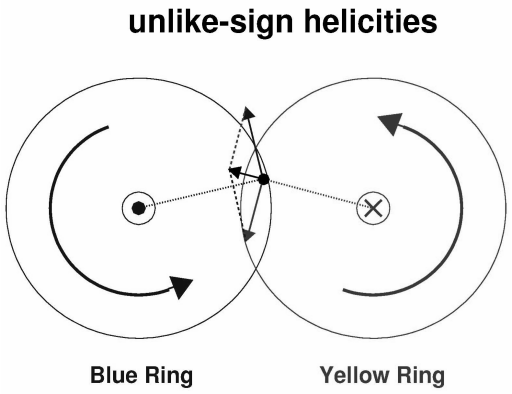
k_T larger



k_T smaller







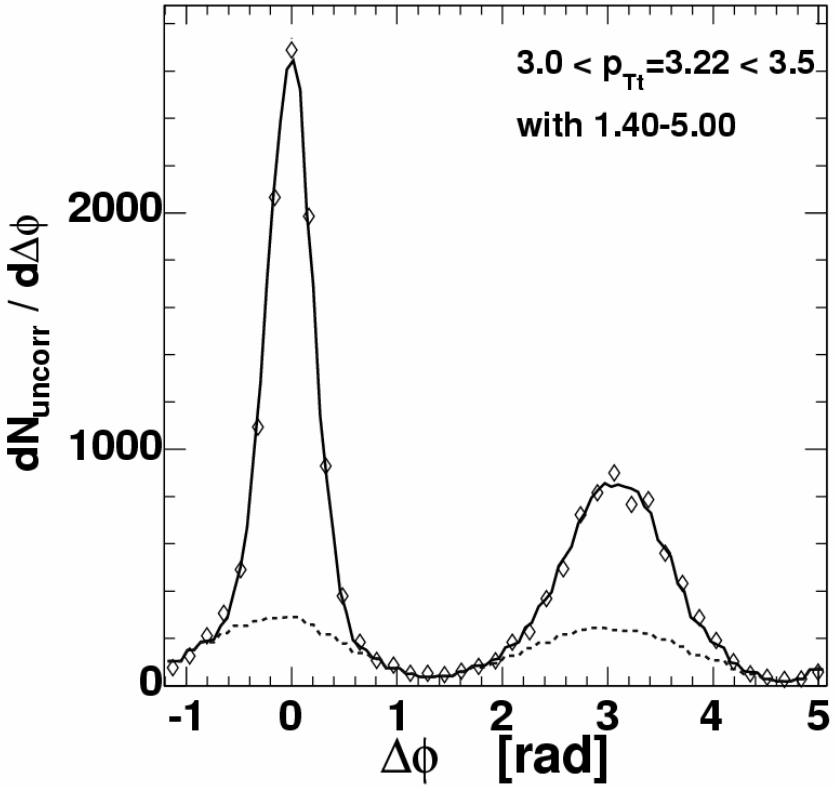
e.g., Meng Ta-chung et al., *Phys. Rev. D 40 (1989)*

Azimuthal correlation function

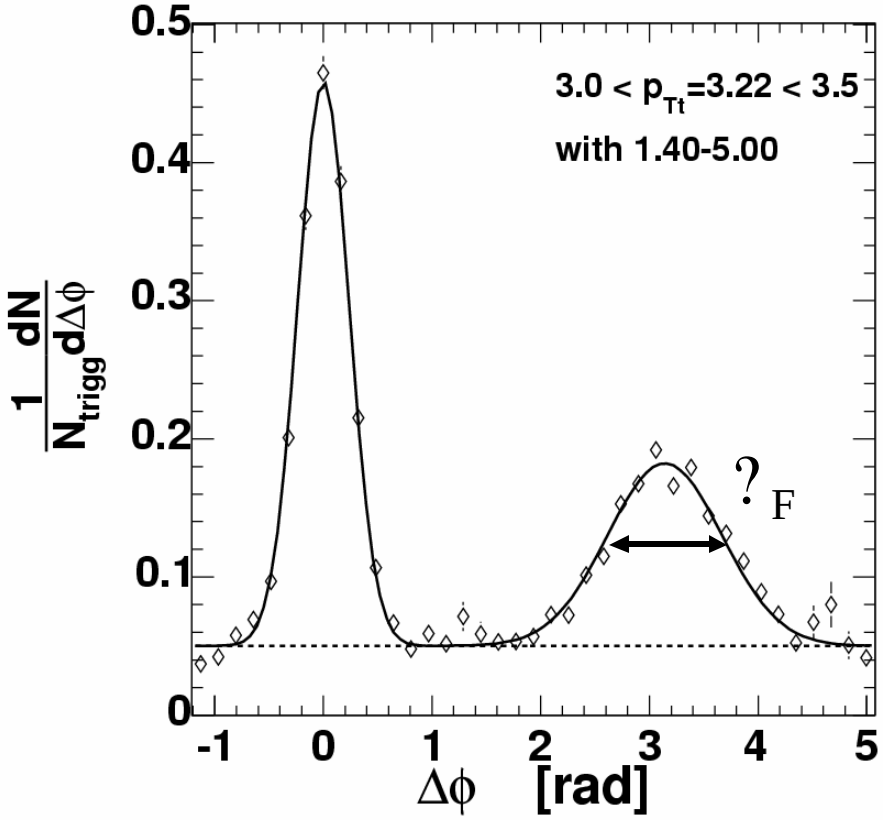
$$C_{ij}(??) ? norm ? \frac{dN^{real}_{ij}}{d??_{ij}} / \frac{dN^{mixed}_{ij}}{d??_{ij}}$$

?° - h? correlation functions

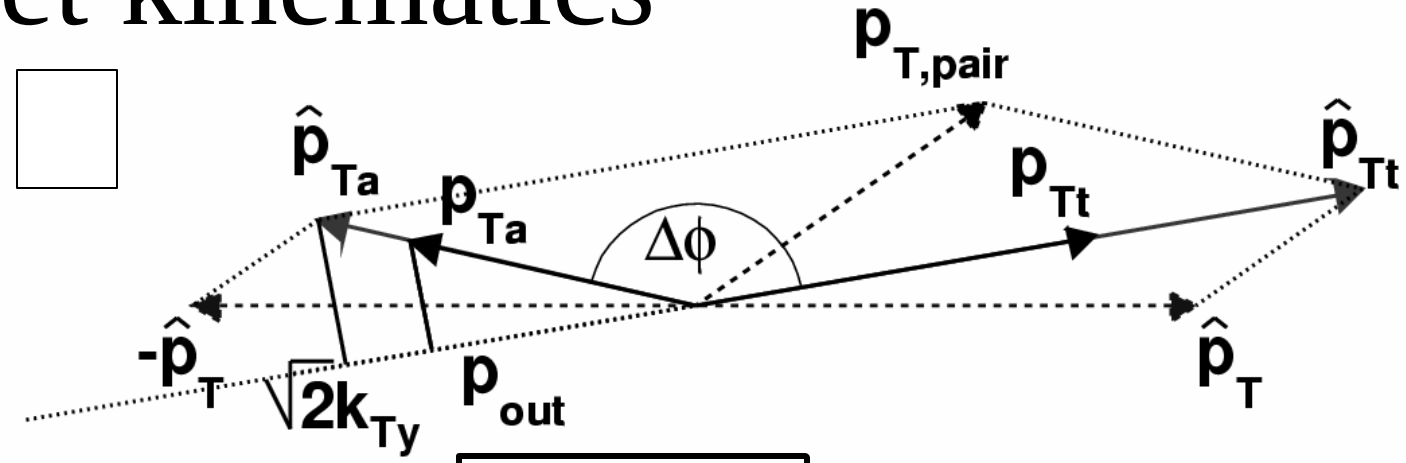
Not corrected for acceptance



Corrected for acceptance

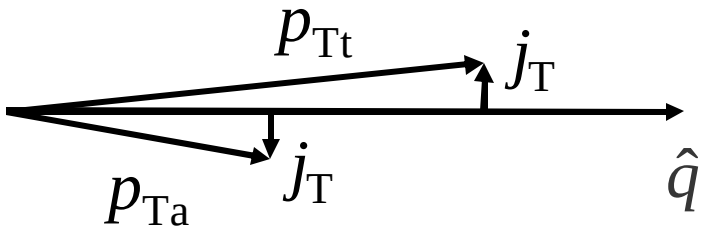


Jet kinematics



$$?p^2_{out}? = ?\,p^2_{Ta}\ \sin^2???? \boxed{2?\,k^2_{Ty}?\,?z^2_a?}\ ?\ 2?\,k^2_{Ty}??z^2_t?x^2_h \qquad x_h = p_{Ta}/p_{Tt}$$

$$\sqrt{\left\langle j_T^2 \right\rangle}\ ?\ \sqrt{2}\,\frac{p_{Tt}\,p_{Ta}}{\sqrt{p_{Tt}^2\ ?\ p_{Ta}^2}}\ ?\ {}_N$$



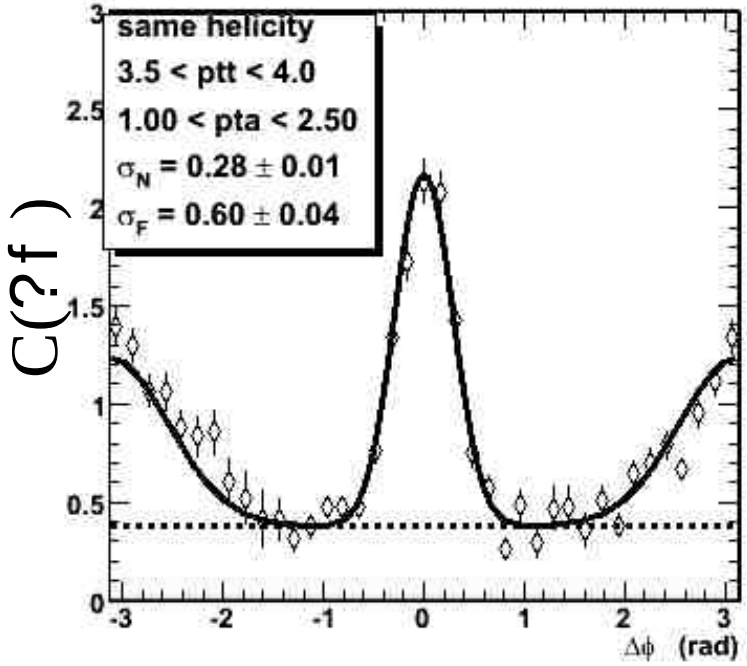
$$\hat{x}_h^{?1}\left\langle z_t \right\rangle \sqrt{\left\langle k_T^2 \right\rangle} \quad ? \quad x_h^{?1}\sqrt{\left\langle p_{out}^2 \right\rangle ?\left\langle j_{Ty}^2 \right\rangle (1\ ?\ x_h^2)}$$

partonic $\hat{x}_h\ ?\ \dfrac{\left\langle \hat{p}_{Ta} \right\rangle}{\left\langle \hat{p}_{Tt} \right\rangle}$ hadronic $x_h\ ?\ \dfrac{p_{Ta}}{p_{Tt}}$

Spin Sorted Analysis

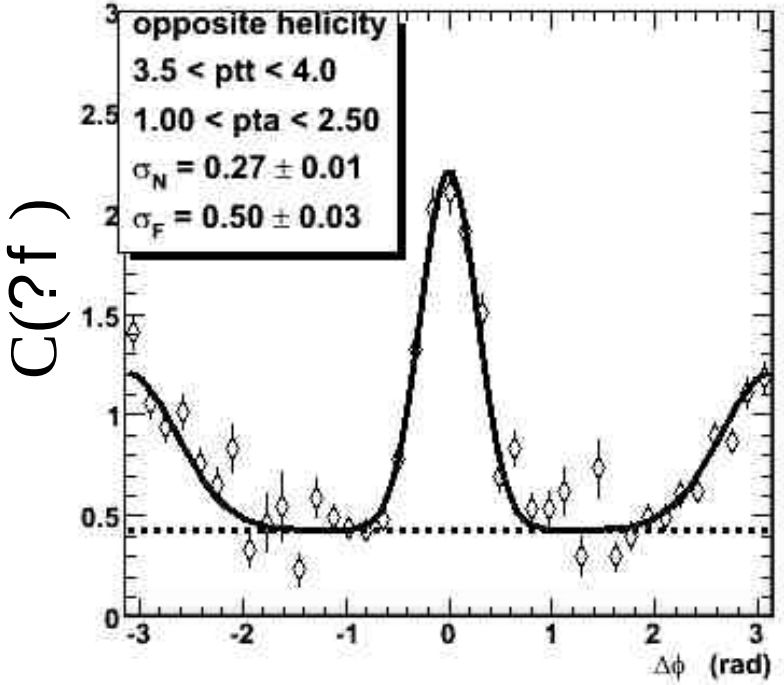
- Do exactly the same analysis sorted on same and opposite helicity bunch crossings, extract $\langle zkt \rangle_{RMS}$ and look at the difference.

Same Helicity



?f

Opposite Helicity



?f

Run03 Data

Like sign

Unlike sign

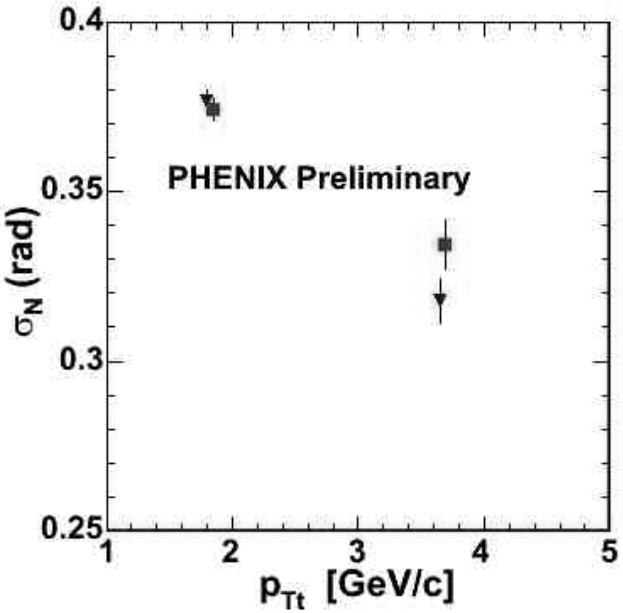
trigger p^0

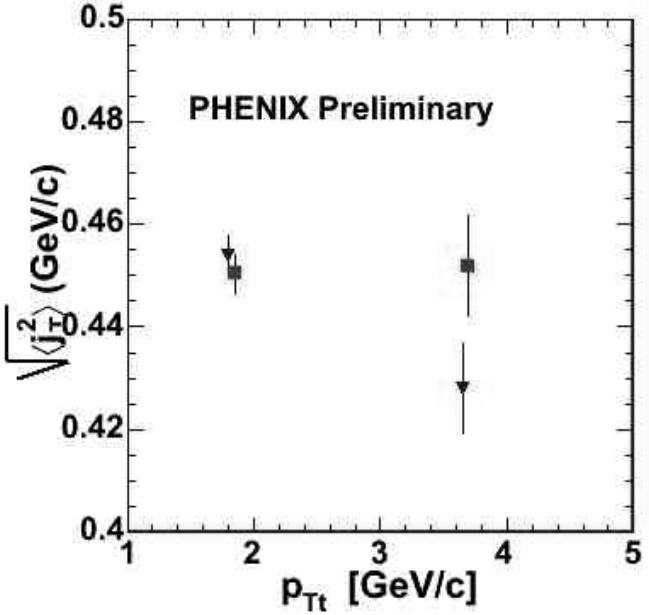
$1 < p_{Tt} < 3$ Gev/c

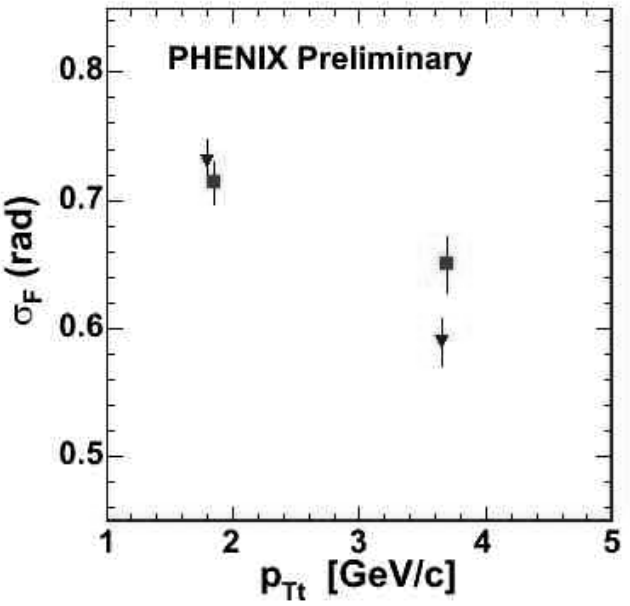
$3 < p_{Tt} < 7$ Gev/c

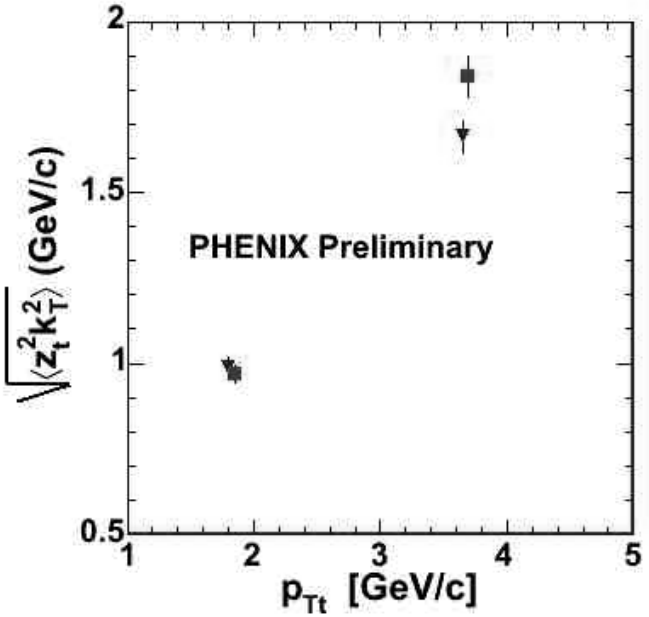
Associated h?

$1 < p_{Ta} < 2.5$ Gev/c



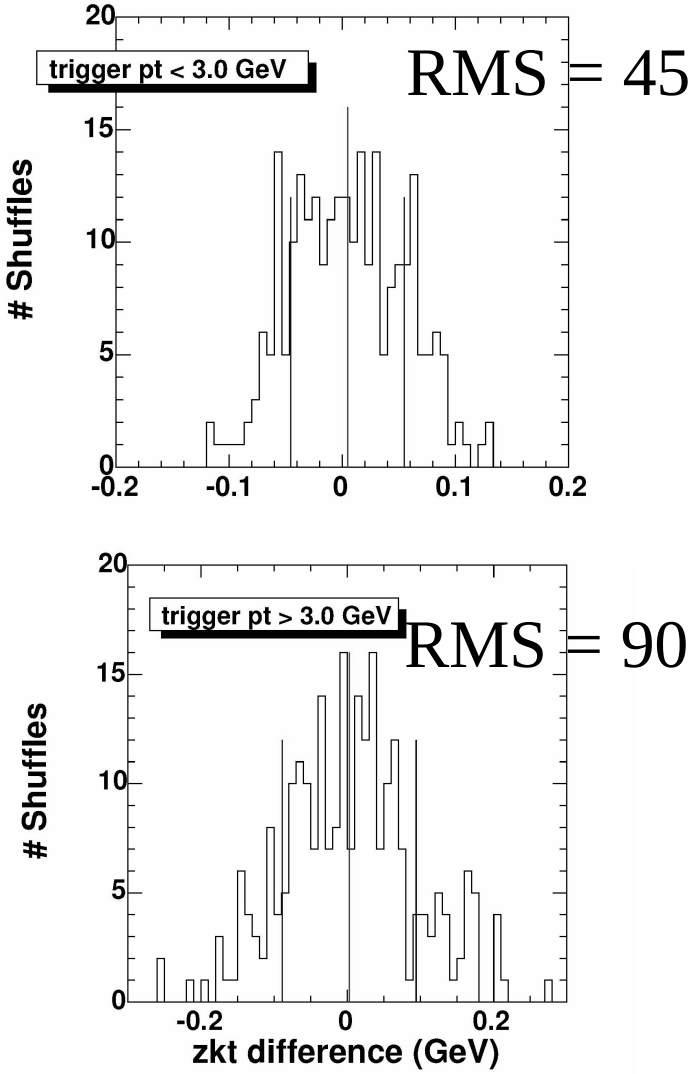






Systematic Check

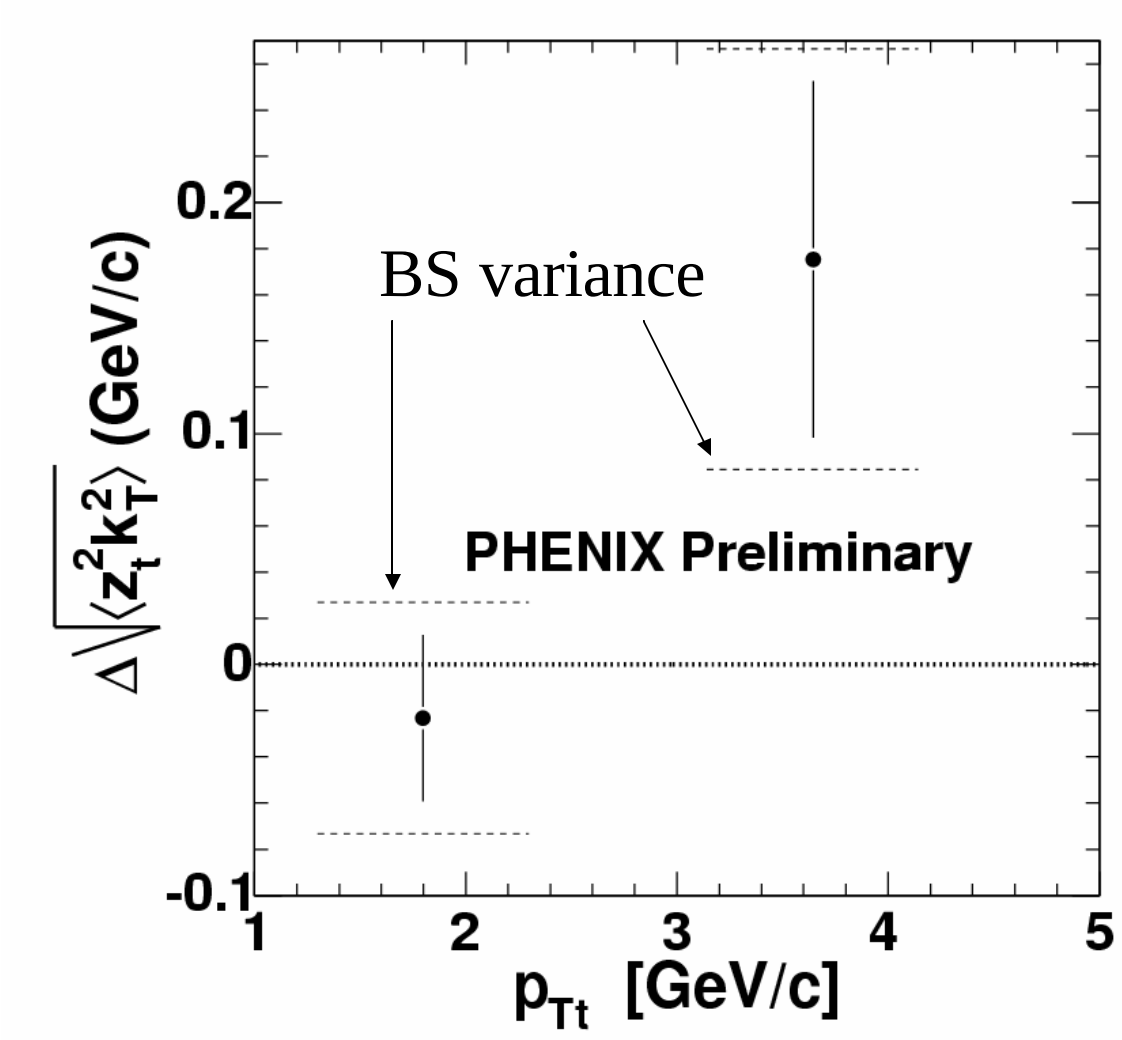
- Helicity assignments are randomized, and then the k_T difference calculated for each randomized set.
- The width of the distribution for all the randomized sets should be the same as our statistical errors on the previous plot.



Run03 Data

Its too early to make a definite statement about the apparent excess as the systematic uncertainties are being evaluated.

However, there is an ongoing analysis of 10x more stat. and 2x better polarization in run05 ✍ should yield a definite answer.



Summary

- We have an analysis tool that allows us to measure k_T - initial state transverse momentum of partons.
- We are studying this effect in longitudinal spin-sorted collisions to see if there is a spin-dependent coherent component of k_T.
- Is there a connection to parton OAM? Theoretical guidance needed!

Outlook

- Run05 has ~x10 statistics, so that the uncertainty reduced by factor 2-3.
- It has ~x2 in polarization, so the effect grows by ~x4.